1935

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EAST AFRICAN AGRICULTURAL RESEARCH STATION

AMANI

NINTH ANNUAL REPORT

1936-37

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2 DEC. 1937

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EAST AFRICAN AGRICULTURAL RESEARCH STATION

AMANI

Report for the Period 1st April, 1936, to 31st March, 1937

STAFF LIST.

Director.—*Vacant.*

Plant Pathologist (Acting Director).—H. H. STOREY, M.A., Ph.D.

Entomologist.—T. W. KIRKPATRICK, M.A., Dipl. Agric. (Cantab.), F.R.E.S.

Soil Chemist.—G. MILNE, M.Sc., F.I.C.

Biochemist.—R. R. LE G. WORSLEY, A.R.C.S., B.Sc., Ph.D., D.I.C.

Plant Physiologist.—F. J. NUTMAN, A.R.C.S., M.Sc., D.I.C.

Plant Geneticist.—L. R. DOUGHTY, B.Sc. (Agric.), N.D.A.

Superintendent of Plantations.—F. M. ROGERS.

Secretary and Librarian.—R. E. MOREAU, C.M.Z.S., M.B.O.U.

Botanist.—P. J. GREENWAY, F.L.S.

Assistant Superintendent of Plantations.—*Vacant.*

Assistant Secretary and Librarian.—W. M. NUTTER.

Engineer Mechanic.—T. V. GREENWOOD.

Laboratory Assistant (Plant Path.).—R. F. W. NICHOLS.

Laboratory Assistant (Soil Chem.).—W. E. CALTON, B.A., Dipl. Agric.

Stenographer.—R. BERGNER.

STAFF CHANGES.

Mr. W. NOWELL retired in August. Mr. A. G. G. HILL has been selected as his successor and is expected to assume duty in October, 1937.

LEAVE MOVEMENTS DURING THE YEAR.

	Departed.	*Returned.*
Mr. W. E. Calton ...	—	9th August, 1936.
Mr. H. H. Storey ...	—	19th October, 1936.
Mr. R. E. Moreau ...	10th April, 1936.	14th November, 1936.
Dr. R. R. Worsley ...	9th July, 1936.	19th February, 1937.
Mr. T. W. Kirkpatrick	30th March, 1937.	—

PUBLICATIONS.

The following papers contributed to scientific journals by members of the staff have been treated as Station memoirs and distributed to our correspondents generally during the year under review:—

33. A Contribution to the Ornithology of Kilimanjaro and Mt. Meru. R. E. Moreau. *P. Z. S. London,* 1935, pp. 843-891.

34. The Insecticidal Properties of some East African Plants: 2. *Mundulea suberosa* Bentham, Pt. I. Insecticidal Properties. R. R. Worsley. *Ann. Appl. Biol.,* Vol. 23, No. 2, pp. 311-328. 1936.

35. Mundulea Fish Poison. P. J. Greenway. *Kew Bull.,* No. 4, 1936.

36. A Provisional Soil Map of East Africa (Kenya, Uganda, Tanganyika and Zanzibar) with explanatory memoir. G. Milne in collaboration with East African Soil Chemists. Published by the Crown Agents for the Colonies, London, 1936.

The undermentioned Station memoirs are in the press or have become available only since the last annual distribution was made:—

Breeding Seasons of Birds in East African Evergreen Forests. R. E. Moreau. *P. Z. S. London,* 1936, pp. 631-653.

Chromosome Behaviour in relation to Genetics of Agave: I. Seven species of fibre Agave. L. R. Doughty. *J. Genet.,* Vol. 33, No. 2, pp. 197-205. 1936.

Rotenone I: The Determination of Rotenone. R. R. Worsley. *J. Soc. Chem. Ind.* (Transactions), Vol. 55, pp. 349T-357T. 1936.

The breeding biology of certain East African hornbills. R. E. Moreau. *J. East Afr. Uganda Nat. Hist. Soc.,* Vol. 13, pp. 1-28. 1936.

Rotenone II: Evaluation of Plants containing Rotenone. R. R. Worsley. *J. Soc. Chem. Ind.* (Transactions), Vol. 56, pp. 15-23. 1937.

An Inexpensive Recording Manometer. F. J. Nutman. *Ann. Bot. N.S.* 1 (1), pp. 205-6. 1937.

Agave Fibres. Pt. I. F. J. Nutman. *Emp. J. Exp. Agric.,* Vol. 5, pp. 75-92. 1937. Pt. II in press.

A new virus disease of maize transmitted by *Cicadulina* spp. H. H. Storey. *Ann Appl. Biol.* In press.

Comparative breeding biology of the African hornbills. R. E. Moreau. *P. Z. S. London.* In press.

Colour vision in the triungulin larva of a Strepsipteron (*Corioxenos antestiae* Blair). T. W. Kirkpatrick. *Trans. R. Ent. Soc. London.* In press.

Studies of the Physiology of Arabica Coffee: I. Photosynthesis of coffee leaves under natural conditions. F. J. Nutman. *Ann. Bot.* In press.

Soil conditions and two East African vegetation types. G. Milne. *J. Ecol.* In press.

Insecticidal Properties of some East African Plants: III. *Mundulea suberosa* Benth. Part 2. Chemical constituents. R. R. Worsley. *Ann. Appl. Biol.* In press.

Insecticidal Properties of some East African Plants: IV. *Mundulea suberosa* Benth. Part 3. Variability of samples. R. R. Worsley. *Ann. Appl. Biol.* In press.

The Avifauna of the Mountains along the Rift Valley in North Central Tanganyika (Mbulu District). R. E. Moreau. *Ibis.* In press.

In addition the following papers, of which a limited distribution of reprints will be made, are in the press:—

A Swahili Dictionary of Plant Names. P. J. Greenway. (Government Printer, Dar-es-Salaam.)

Biological and other notes on East African Birds. R. E. Moreau and W. M. Moreau. *Ibis,* 1937; Part I pp. 152-174; Part II in press.

VISITORS.

East African visitors to the Station during the year include Mr. G. R. Sandford, Treasurer, Tanganyika; Mr. C. F. M. Swynnerton, Director of Tsetse Research; Mr. G. F. Clay, Assistant Director of Agriculture, Uganda; Count Don Mario Caracciolo, Italian Consul-General, Dar-es-Salaam; Dr. G. B. Wallace, Mycologist, Tanganyika; Mr. F. B. Notley, Entomologist, Tanganyika; Mr. H. A. Lindeman, Education Department, Tanganyika; Mr. V. Liversage, Department of Agriculture, Kenya; Mr. L. A. Markham, Forestry Department, Tanganyika; Mr. R. R. Staples, Veterinary Department, Tanganyika.

Overseas visitors include Sir Frank Stockdale, K.C.M.G., C.B.E.; Mr. A. G. G. Hill, Director designate of the Station; Mr. D. Gillett, Gold Coast; Mr. G. van Son, Pretoria; Mr. S. E. Sanderson, Ecuador; Drs. Gillett and Leeson, London School of Tropical Medicine; Dr. H. Cloos, Bonn; Dr. E. Mai, Berlin; Mr. P. K. Norris, U.S. Department of Agriculture; Messrs. R. L. Steyaert and J. M. Vrijdagh, Belgian Congo; Mr. M. O'Brien, New Zealand.

In addition, Mr. B. Cooper spent six months at the Station working under the direction of the Entomologist; and Mr. D. Vesey-Fitzgerald made Amani his base for some weeks while collecting parasites of coconut pests on behalf of the Seychelles Government.

REPORT OF THE ACTING DIRECTOR.

The year under review has been one of changes. In April, 1936, Mr. W. Nowell left pending retirement from the Directorship after ten years' service to the Station. He found Amani scientifically derelict; under his guidance it changed first to a going concern still uncertain of recognition and hampered by grave material difficulties; and at length he left a research station in fruitful and enthusiastic working, with world-wide scientific connections.

Mr. Kirkpatrick assumed charge of the Station on Mr. Nowell's departure; and handed over to me on my return from leave in October, 1936. Mr. A. G. G. Hill, who has been selected to succeed Mr. Nowell, is expected to assume duty in October, 1937. Mr. Hill paid an introductory visit to Amani in March, 1937. This coincided with a visit from Sir Frank Stockdale, Adviser in Agriculture to the Secretary of State, and the opportunity was taken to discuss the research programme and financial and administrative policy of the Station.

Research.

Research has made substantial progress, in spite of some inevitable slowing down in certain sections as a result of leave movements or by reason of officers having to undertake other duties. The visible output, in the form of published memoirs, continued to increase, as the preceding list bears witness. In their several reports research officers described the work upon which they have been employed and the progress made during the year.

The contribution that soil science can offer to the progress of agriculture in East Africa in well shown by the year's work of this section. The first phase of the soil research programme culminated in the publication in 1936 of a provisional Soil Map of East Africa. It represents the combined work of all the Soil Chemists of the East African dependencies, co-ordinated at two Conferences of these workers, but owing much to the personal influence of Mr. Milne, who was entrusted with the preparation of the map and its accompanying memoir. This publication has attracted well merited attention; in few other countries of such large area and sparse population has anything similar been attempted.

This Soil Map appeals primarily to the student. The agriculturist seeking practical information upon a local problem in Africa will be disappointed, as indeed he is warned in the introductory text. The second phase of the soil research programme is designed to bring the knowledge of the individual soil types, as thus roughed out, into relation with the problems of their agricultural utilization. From the beginning this aspect

of the study of soils has been kept in view; but only as knowledge grew could deductions bearing on utilization be safely drawn.

During the year Mr. Milne prepared a report upon a soil reconnaissance journey through parts of Tanganyika. The reader cannot proceed far in this report without appreciating that fundamental soil research on modern lines affords a guide to utilization and management that could have been obtained in no other way. Mr. Milne demonstrates that pedological knowledge could have saved past errors; and that in taking a decision upon a major point of agricultural policy the administrator cannot afford to disregard the pedologist.

This report received only a limited circulation to persons directly interested. Wider dissemination of the information will be attained by the publication of scientific reports upon limited areas or soil-types, as more detailed information accumulates; while the practical applications of soil research will be explained in articles in the East African Agricultural Journal.

The first of these, to appear as one of a series of *Essays in Applied Pedology*, deals with the soils of the East Usambara Mountains. Although of direct application to only a small area, this paper has lessons for all who are attempting crop-production on the laterized red earths of East Africa, and indeed for the plantation industry generally. It has a particular bearing upon the redevelopment of the Kwamkoro estate, which is now being undertaken as a part of the Station's activities. The findings of the pedologist and the means to be adopted to carry out his recommendations will be further discussed in the section devoted to Kwamkoro.

Work in the sections of Entomology and Plant Pathology has been affected by the administrative changes to which reference has been made. Nevertheless, in continuation of his researches on the ecology of insects attacking the coffee bush, the Entomologist has completed a detailed memoir upon the ecology of *Antestia*, paying particular attention to a parasite belonging to a hitherto little known group. This is a substantial contribution to pure entomology as well as to knowledge of an important local pest. Under his direction, a voluntary worker, Mr. B. Cooper, undertook one part of the investigation. The need for extension of these studies to include the nutrition of *Antestia*, concerning which a conflict of opinion exists, has become evident.

The main occupation of the Plant Pathological section has been the study of the mechanism whereby insects transmit plant viruses. This has continued for a number of years during which important results have been obtained. Recently accumulation of data has outrun interpretation and much original information awaits publication.

Progress is reported in the investigations of Cassava virus diseases, and it seems likely that certain obscure features in insect-transmission of mosaic disease will be explained in due course. The general problem is one of grave importance to native agriculture and the working out of effective control measures would confer far-reaching benefits.

The Biochemist was absent on leave for two-thirds of the year. Nevertheless he completed a series of papers upon the chemical and biological assay of the toxic constituents of Derris and Mundulea. They form the basis for studies on the variation of toxicity in relation to the strains of the plants and to the circumstances in which they have been grown. Information on these points is essential if one or the other of these species is to be established as an economic crop in East Africa. Furthermore the preliminary work has laid the foundations for physiological studies of the manner in which the toxic materials are formed in the plant. This is a field of research offering considerable promise.

In recent years the Physiologist has developed a line of work that may be termed " Physiological Ecology ": it comprises the study of variations in the plant's physiological functions under the changing conditions that it naturally encounters in the field. For much of this work special apparatus has had to be devised, since the physiologist's apparatus is generally suitable only for the laboratory and cannot be operated under plantation conditions. Important results have been obtained during this year bearing on the manner in which shade influences the physiological processes of the Arabica coffee bush.

Hitherto the problem of the correct use of shade for coffee has remained without a general solution. It has been extensively studied by the agronomist, but of necessity empirically for lack of a fundamental basis. Mr. Nutman's researches on photosynthesis by the leaves of *Coffee arabica,* in full sunlight and under shade, promise to provide at least some of the fundamental knowledge needed. If we may assume that shade exerts its chief effect on the plant by controlling photosynthesis and that conditions favouring a maximum rate of photosynthesis are beneficial, then we may expect that Mr. Nutman's work will in time lead us to the ideal policy for shade. With this guidance the agronomist will be able to devise and test methods of shading coffee, that will give in each locality the nearest practicable approach to this ideal.

It has become evident that plant physiology, on the lines that Mr. Nutman has developed, can contribute much to the advancement of agriculture. It is therefore satisfactory to be able to record that provision has been made by the contributing governments for the appointment of a second physiologist for the Station. This increase of staff will permit of an extension

of the work on coffee and also a beginning on other crops. These will include sisal, which hitherto has been worked on by the physiologist mainly in the little known fields of its leaf-anatomy and fibre-technology. Necessary and fruitful though this work has been, it has left the subject of sisal physiology hardly touched up to the present.

In the breeding of Agaves the Geneticist reports good progress and results of economic importance may be expected in the next few years. At present the main objective is a type of Agave that will yield more heavily than the common Sisal and will at the same time give a fibre not inferior in quality. Some of the hybrid plants already raised give promise of achieving this purpose. A second objective is the production of a plant giving fibre of better quality than sisal; but at present we are almost without guidance as to the points of quality that would be appreciated by the market.

The Station is indebted to Colonel the Hon. M. T. Boscawen for contributing to the collection a large number of Agave species obtained from overseas.

The improvement of the yielding capacity of coffee is an important but at the same time exceedingly difficult task for the Geneticist. Apart from the great complexity of the genetical problem, technical difficulties are encountered owing to the large influence that environment seems to exert on yield. When furthermore it is remembered that the plant requires five years to reach maturity, it becomes doubtful whether the augmentation of yield is one that can profitably occupy the time of the plant-breeder. Evidently the vegetative propagation of selected clones affords a more hopeful means of multiplying material having the desired characters.

On the other hand where qualitative characters are concerned the plant breeder may well have something to contribute to the improvement of Arabica coffee; and Robusta coffee, having a genetically simple constitution, may prove to be amenable to improvement both in qualitative and quantitative characters.

Meanwhile the Geneticist has continued cytological studies of his plant material, both as a guide in formulating his breeding programme and in interpreting his results. An account of the cytology of certain Agave species has been published.

The Systematic Botanist reports the performance of a large amount of work for other workers in East Africa and overseas. This has made increasing calls on his time and allowed him little opportunity for original field survey. He has combined his notes made during a number of years into a valuable dictionary of Swahili plant-names. The Herbarium has been maintained in good order and further augmented.

Mr. Moreau, although absent from the Station on leave during a part of the year, has continued to add to his important series of papers on the ecology and biology of East African birds.

The demands of research officers in connection with the raising and maintenance of plant material continue to be efficiently met by the Superintendent of Plantations and his staff. These demands emanate mainly from the Geneticist, whose selections and seedlings of *Agave* spp. and *Coffea* spp. now occupy a considerable area. In a lesser degree work has been done for the Biochemist and Plant Pathologist in the propagation of insecticide and essential oil plants and Cassava. This work tends to increase. The majority of the Amani plantations, inherited from the previous regime, are now only of historical and botanical interest. Nevertheless certain of the crops still offer possibilities of economic production, or might do so with an unforeseen turn of the markets; and it is regrettable that economies in recent years have enforced some neglect of maintenance and crop-recording. There is an evident need for a larger allocation of funds for the plantation staff.

On the other hand the inherent limitations of the Amani estate for comparative field trials—in particular the steep and irregular topography—causes growing reliance to be placed on the experimental stations established by the Tanganyika Department of Agriculture. I am able to record the maintenance of a spirit of co-operation between the staffs of Amani and the Sisal and Coffee Experiment Stations at Ngomeni and Lyamungu. I would express my appreciation of the facilities granted by the authorities controlling these stations

Plant Introduction and Distribution.

With the growing interest of the planting community of East Africa in a diversification of crops, the distribution of planting material has assumed greater importance in the Station's activities. Details of the material handled appear in the report of the Superintendent of Plantations.

The greenhouses of the Central Quarantine Station have been only partly occupied during the year. Sugar cane varieties constitute the bulk of the material, although a few *Agave* spp. and other succulent plants have been handled. An increasing demand is now arising for the services of the Station. During the forthcoming year the houses will be filled to capacity with sugar canes and it may be necessary to postpone orders for new varieties from overseas until space can be made available.

To meet this difficulty and to prevent the duplication that has occurred under a divided system of ordering, the procedure of importing sugar cane has been revised with the concurrence of Directors of Agriculture. Under the new system all requests

for varieties are passed to Amani; orders are then placed with the most favourable correspondents overseas and as quarantine space becomes available. By omitting a multiplication stage in the open after release from quarantine, the extension of varieties to the field scale will be accelerated.

During the course of its existence, the quarantine station has intercepted one variety carrying mosaic disease, and one other was destroyed on suspicion. The one diseased variety was contained in an early private importation from an unknown source in India. The freedom from disease of recent importations is evidence of the soundness of the policy of careful choice of the source whence material is obtained. The authorities in charge of the Natal Sugar Experiment Station, the Coimbatore Sugar Cane Breeding Station and the Washington Quarantine Station have freely met our many requests. No disease has been detected here in material emanating from any of these institutions.

The demands for planting material of Blue Sisal (*Agave amaniensis*) have exceeded even the large quantities that are now becoming available. Owing to the danger of spreading the Mexican Sisal Weevil, distribution of suckers has been confined to the Tanga province, where the pest is already established. To date nearly 90,000 suckers have been supplied to sisal growers from Amani and by the officer in charge of the Ngomeni Sisal Experiment Station, where a plantation was established with the first of the Amani material to become available. Distribution to weevil-free areas has been confined to bulbils. Fortunately the Amani plantations have begun to pole freely. Some 90,000 bulbils have been provided this year, and two to three times this number should be available during the forthcoming year. The material is allocated, in consultation with sisal planting organisations of Tanganyika and Kenya, in proportion to production of fibre.

The policy in the handling of *Derris elliptica* has presented difficulties. The Amani stock originated with three plants imported in 1928 from the Royal Botanic Gardens, Kew. By great good fortune the clone so obtained appears to be one producing roots of high rotenone content and so of desirable market qualities. Once these merits were recognized, our first function was to multiply the material as rapidly as possible. But at the same time there was an obvious need to investigate from every aspect the commercial possibilities of Derris as a crop for East Africa; and particularly by experiments to determine the yields obtainable and costs of production. Multiplication and crop estimation are incompatible in the same material; plots were established at Kwankoro in 1935, that might have served the second purpose had not the need for multiplication forced us repeatedly to strip the plants of all shoot growth to provide cuttings.

The present position is that the 1935 and 1936 plantings will be maintained as a source of cuttings as long as the demand continues. A part at least of the 1937 plantings will be allowed to grow unhindered, as an experimental commercial planting while accurate cost accounts will be kept.

Hitherto no general distribution of planting material of Derris has been made, all available cuttings being used for further developments under Amani control. The first general distribution will be made in 1937, when it is expected that between 50,000 and 100,000 cuttings will be offered for sale at a price fixed so as to cover the cost of production. It might have been preferable to withhold material until we could issue it with a firmer assurance of favourable economic prospects, but this would have entailed delay of three years at least which is undesirable in view of the insistent demand from planting interests.

Indeed the delay in meeting this demand has already led to some dissatisfaction and to attempts to import planting material from overseas. In his report the Biochemist sounds a warning of the harm that might be done to an East African Derris industry if low grade plants become established. As he points out, a large production of high grade material is developing in the Far East, and the market for low grade material may be expected in time to disappear. As an outcome of negotiations originally set in train by Dr. Worsley, the importation of *Derris malaccensis* into East Africa is now prohibited. But the danger to the prospective industry does not end with the prohibition of that low-grade species. It is becoming evident that the main difficulty with which the Derris industry of the Far East must contend is the existence there of low grades of *Derris elliptica* as well as *D. malaccensis,* and consequent great variability in the roots offered for sale. If developments in East Africa could be confined solely to the single high-grade clone now established the exported product might be expected to show a uniformity that should assure it a good reputation on the market. For the general welfare of the industry it is thus imperative that low-grade types of *Derris elliptica* should not be introduced in East Africa, and that steps should be taken to prevent the extension of any such types that may have been already established.

The large distribution of cuttings of the Amani clone that can be made in 1937 and subsequent years should remove any justification for importing material from overseas for commercial propagation. Meanwhile Amani is continuing to introduce varieties for comparative trials. None of these will be released for general planting until their undoubted superiority has been shown.

Considerable interest has developed in Cinchona production, leading to demands for seed both from Departments desiring to carry out the trial plantings recommended by the Colonial Advisory Council and from private planters. Unfortunately an unfavourable season caused an almost complete failure of the seed-crop from the Amani *Cinchona ledgeriana* plantations, and we were forced to refuse the majority of the orders for this species. To meet the more important demands from Departments, seed of *C. ledgeriana* was purchased from the Superintendent of Cinchona Cultivation in Bengal. The prospect of a good seed crop in 1937 appears to be favourable.

The whole of the seed from the few mature *Aleurites montana* trees at Amani was used for developments at Kwamkoro. A crop of some 80-90 lb. of seed is expected in 1937, of which about 50 lb. will be distributed to Departments.

At the Conference for the Co-ordination of Agricultural Research held at Amani in 1936, a request was made that Amani should establish a collection of Yams (*Dioscorea* spp.). Through the co-operation of officers of the Tanganyika Department of Agriculture and the Director of the Botanic Gardens, Peradeniya, a considerable collection has been brought together and promises of material from West Africa have also been secured. In due course the material will be distributed to Agricultural Experiment Stations.

A desultory demand for miscellaneous seeds available at Amani has continued, and has indeed been stimulated during the past year by the publication of a revised list of the seeds and plants available. These have been supplied to the public, as heretofore, at a charge that covers the cost of collection and preparation.

The Redevelopment of the Kwamkoro Estate.

A scheme for the experimental redevelopment of the almost derelict coffee plantations of this estate was adopted in 1935. A grant for the purpose was made from the Colonial Development Fund, and work began during the latter half of 1935, under the executive control of the Amani Superintendent of Plantations. The intention was to investigate whether profitable plantation industries could be established in the old Usambara clearings, by planting trial areas with Arabica coffee grafted on to Robusta rootstocks, with Robusta coffee of selected strains, with *Aleurites montana, Cinchona* spp. and *Derris elliptica*. No new felling of the natural forest was to be undertaken.

Progress along the lines of extensive planting of these crops, which is recorded in detail in the Report of the Superintendent of Plantations, has been rapid. The clearing of the land from its old coffee and heavy growth of Grevillea shade, the

raising of plants in the nursery and their establishment in the plantation have been heavy work; that over 250 acres should have been so developed within 15 months reflects great credit upon Mr. Rogers, who has achieved this in addition to performing his ordinary duties as Superintendent of the Amani plantations.

The experiment is essentially one in the management of an estate under a diversity of crops. Development on an experiment station layout, with replication of small plots, was never considered; since the broken topography renders the estate entirely unsuitable for such a purpose. An evident need of an experiment in commercial exploitation is accurate cost accounting for each operation on each crop. Fortunately daily labour distributions, maintained by the Superintendent of Plantations from the beginning, have made it possible to apportion the early expenditure to the separate crops with reasonable accuracy. During this year a system of cost accounting has been evolved that is workable by the limited staff available and has indeed worked successfully from the beginning of 1937. The system was devised by Amani officers in consultation with Mr. V. Liversage, Economist to the Kenya Department of Agriculture, who by permission of his Director visited the Station in January, 1937, for this purpose.

We may thus anticipate that the experiment will in the course of time answer the first question asked: whether any or all of the proposed crops can be successfully grown on an extensive system of management. But it must be many years before the experiment can give any assurance that a stable plantation industry can be established. Meanwhile the planter will not wait; already one estate adjacent to Amani has been reopened with a view to commercial production of some of the crops that we now have under trial. Our example is thus encouraging development that is quite premature and may well suffer the fate that overtook the Arabica coffee industry on the same site.

This possibility is not very remote. The crops chosen for the new development have shown that they are more able to tolerate the Usambara conditions than is Arabica coffee; but we have as yet little guidance as to their ability to produce crops at an economic level over a term of years. On theoretical grounds the prospects of stable production by extensive management of any crop are not favourable.

This statement is based on a report upon the soils of Kwamkoro prepared by Mr. Milne at my request. This report formed the basis of the paper on agricultural conditions in the East Usambaras, to which reference has already been made.

It explains the anomaly, hard for the layman to grasp, that luxuriant forest can exist on an essentially poor soil; that the naturally low fertility is largely lost when the forest is felled; and that the soil is deficient even in reserves that might provide fertility in the future. The conclusion drawn is that fertility must be restored and maintained from a source outside the area cultivated. Perhaps therefore the most important problem for the experiment to solve is the means that can be economically adopted to effect this restoration.

The key may be found in the herd of cattle that has successfully maintained itself on pastures provided by the old coffee plantations. It may be possible to use the cattle in conjunction with compost-pits, to collect fertility from a wide area and concentrate it upon a small area of crops. Probably some imported fertility, in the form of artificial manures, will also be required; if so their application through the medium of the compost-pit is desirable, and probably the only method likely to achieve results.

This is but one part of the intensive treatment of the crops that may be needed. In the present developmental phase, it is the most important; because upon the siting of plantations must largely depend the possibility of economically manufacturing and applying compost-manure. The chief cost of these operations is transport, which on the steep hill-slopes must largely be done by human labour. Thus economy in transport becomes an important consideration in lay-out; by placing plantations in relation to sites of cattle-sheds, sites for compost-making and areas of cleaned land carrying natural or planted vegetation for conversion into compost, transport costs may be reduced to a minimum. Such a layout is not impossible at Kwamkoro, where the old plantation areas are large compared with the areas to be redeveloped.

The ten acres of grafted Arabica coffee have been developed from the start on an intensive system since it early became evident that without manure the plants could never be established. (See Director's remarks, 8th Annual Report, 1936, p. 8.) Ten acres of Robusta will be similarly treated. Any new plantings of other crops will be so sited as not to preclude the application of intensive methods, should this become desirable in the future.

It may be asked whether crops such as Robusta coffee and Aleurites, giving at best a small margin of profit, can bear the cost of intensive management. To this question the experimental development should give an answer in the not too distant future. And if meanwhile the extensive system of management shows signs of failure we should be in a position to offer planters sure guidance in the methods for arresting the decline.

General Administration.

The year's revenue shows a small surplus over expenditure, and a satisfactory reserve balance is carried forward to 1937 (see Appendix A). A surplus on the year's running has, however, been rendered possible solely by savings on the personal emoluments of the post of Director, which remained vacant for half the year. This is one of a series of occurrences that have in recent years saved the Station from the full effects of the financial stringency that the present budget imposes. Owing to the normal course of salary increments, the Station income being fixed, the proportion of the annual expenditure estimated to be required for personal emoluments has risen from 70 to 80 per cent.; consequently the proportion available for other charges has fallen from 30 to 20 per cent. Meanwhile the cost of services that must be met from this diminished proportion has shown no tendency to fall, but rather under some heads to rise.

In an entirely normal year the Station could function efficiently, only by making heavy calls on the reserve funds.

In accordance with the intention explained in the Eighth Annual Report, the " old Kwamkoro " account has been closed. The balance is being transferred with the approval of the Secretary of State to the Amani reserves.

The Amani buildings have been maintained in reasonably satisfactory order, although repairs, even at the present high rate of annual expenditure, barely keep pace with the ravages of termites in the older houses. The partial rebuilding of some will have to be faced within the next few years.

A second hydro-electric plant, of double the capacity of the original one, has been brought into operation. The installation was done by the Station Engineer, and inspected and tested by Mr. J. E. Brunnen, Electrical Engineer to the Department of Posts and Telegraphs. A considerable reorganization of the electrical transmission system has become necessary to conform to regulations shortly to be issued by the Tanganyika Government.

The East African Agricultural Journal.

The editing of this Journal continues to be the duty of the Director. The whole staff has contributed material to the publication. Not only has the Station provided all editorial notes and a number of articles, but it has also been responsible for the majority of the reviews and for the selection of the material reprinted from other journals.

The flow of original articles from official and unofficial contributors has sufficed to fill the numbers without undue use of reprinted matter, but has been insufficient to give a reserve of material, from which, by selection, balanced numbers might be planned.

H. H. STOREY,
Acting Director.

REPORT OF THE PLANT PATHOLOGIST.

I was on leave from March to October, 1936; and since my return to the Station I have acted as Director; although I have thus had little opportunity to take a direct part in the research in progress in the plant pathology laboratory, I am able to record progress in several lines of work, mainly those entrusted to my assistant, Mr. R. F. W. Nichols. I wish again to place on record the efficient and reliable service that he has rendered.

Virus Diseases of Plants.

The mechanism involved in the transmission of plant viruses by insects.—For several years I have devoted much time to the study of this somewhat neglected but important subject, and results have been recorded from time to time in my annual reports. The apparent progress—as revealed by published papers—has recently slowed, owing to difficulties in solving a key problem, to which I have referred in my last two reports.

This key problem is the manner in which the insect inoculates a virus into a plant. I have already reported that my experimental evidence appears not to support the generally held view that the insect's saliva is the vehicle that carries the virus into the plant but affords no indication of an alternative vehicle. The intention, recorded in my last report, of publishing results in their present inconclusive form was not proceeded with; mainly in consequence of discussions held with a number of workers in England. I am indebted to Mr. F. Y. Yates of Rothamsted for pointing out a flaw in the conclusion drawn from certain experimental data, which has since been made good by further work; and to Prof. D. Keilin, F.R.S., of Cambridge, for a suggestion that may lead to a solution of the problem. The special equipment necessary for testing this suggestion has been assembled; but other duties have prevented me from undertaking so far the experimental work required.

Recent studies have again brought into prominence the subject of the inheritance of the ability to transmit. In 1932 I published an account of breeding work with *Cicadulina mbila,* which showed that " activity," the power to transmit the maize streak virus, was inherited as a dominant Mendelian factor linked with sex. Similar studies of *Cicadulina zeae* and *C. storeyi** revealed anomalous behaviour apparently inexplicable on the preceding hypothesis. I have since encountered similar

* This species was referred to as *C. nicholsi* in my last report. Owing to a misunderstanding, Mr. W. E. China described it under the name of *C. storeyi* (*Bull. Entom. Res.*, 27 : 251).

anomalous behaviour in certain lines of *C. mbila*; and in the hope of obtaining a general solution much time has been devoted during the past year to the breeding of these anomalous families.

Active individuals of *Cicadulina mbila* vary greatly in their efficiency as vectors of the streak virus. This variability shows itself in two ways: (1) in the frequency with which they infect plants during contacts of short duration, and (2) in the length of time that they remain infective after removal from a diseased plant. We may reasonably suppose that (1) is determined by the rate of output of virus by the insect during the period when it is under test; and that (2) is determined by the power of the insect to continue to put out virus without replenishing its stock by feeding on a diseased plant. That is, on the views widely held, (2) is dependent on the insect's capacity to permit multiplication of the virus within its body; although I do not admit that with this species alternatives to the multiplication hypothesis have been definitely disproved.

Work was undertaken to determine whether variability in these two respects is genetically determined. For the first, results were inconclusive, and at present I think it more probable that the insect's potency in inoculation may be physiologically determined. The second type of variability is undoubtedly controlled by genetical factors, and breeding studies have revealed a position of great interest, but great complexity.

Starting with insects having a very low capacity to remain infective, families have been bred and tested up to the eighth generation. These families, from an early stage, showed proportions of active and inactive individuals that could not be fitted to the scheme of inheritance previously established. The results were discussed in England with Dr. R. A. Fisher, F.R.S., and Dr. K. Mather, of the Galton Laboratory of the University of London. They suggested an explanation on the basis of a second genetical factor modifying the dominance of the factor for activity; in certain combinations the modifying factor might prevent the manifestation of activity in an insect although it might be carrying the dominant factor for activity; in other combinations, activity might be only weakly manifested. A full analysis of all the results has not yet been completed, and while much evidence supports this new hypothesis some appears to conflict with it. I expect to publish an account of the work in the forthcoming year.

A paper describing a new virus of maize, transmitted by *Cicadulina* spp. has been published in the *Annals of Applied Biology* (24: 87). There is some fundamental interest in the discovery of a virus that is apparently quite distinct from the

streak group and yet is transmitted by the same species of vectors and by active families alone of these species. The disease is unimportant in the field.

Virus Diseases of Cassava.—A study of the collection of strains of the mosaic virus, to which reference has been made in earlier reports, has been continued.

Considerable advances have been made in the development of a convenient technique for the transmission of the mosaic virus by White Fly (*Bemisia* sp.). I have reported that successful experiments were at first obtained only by exposing the whole plant to the feeding of the insects; any attempt to confine the insects to particular leaves led to failure. This necessity restricted greatly the experimental study of transmission, and without a more manageable technique progress could only be slow. Great improvements have followed recent work; already a reasonably satisfactory technique has been evolved, and further improvements are expected to follow from experiments now in progress. This work has thrown new light on the conditions that are necessary to allow the insect to infect the plant.

The experiment upon the secondary spread of mosaic in the field, which has continued over two and a half years, has now been concluded. Marked seasonal differences in the rate of spread have been demonstrated. An account of this experiment will be prepared for publication in the *East African Agricultural Journal*. I wish to express my thanks to Canon Hellier and the authorities of the Universities Mission to Central Africa for the provision of the land and for supervision of the experiment.

The introduction through quarantine of cassava varieties from overseas has continued. Planting material of 14 varieties has been distributed to the Agricultural Departments of Tanganyka, Kenya, Uganda and Zanzibar. Arrangements were made with the Economic Botanist of the Royal Botanic Gardens, Kew, to obtain, if possible, species of *Manihot* from South America, in the hope that some might prove resistant to mosaic and so serve in a breeding programme aiming at introducing factors for resistance into economically valuable types.

In March, 1936, I visited the Experiment Station of the Kenya Department of Agriculture at Kilifi in order to see the work in progress there upon cassava. Selected varieties from this Station were added to the Amani collection.

Leave Activities.

During my leave, I read a paper on " The Transmission of Plant Viruses by Insects " to the Second International Congress on Microbiology held in London. I also gave an account of

my work to a meeting of British virus workers held at Cambridge. Contact was made with various workers at Cambridge, Rothamsted and London.

Publications.

In addition to the paper published in the *Annals of Applied Biology,* I have contributed semi-popular articles to the *East African Agricultural Journal.*

H. H. STOREY,
Plant Pathologist.

REPORT OF THE ENTOMOLOGIST.

During half the year under review I acted as Director of the Station, and in this period the Secretary was also absent on leave; the time available for entomological work has therefore been limited.

A paper on the ecology of *Antestia,* the Coffee Bug, has been completed and is ready for publication. Part I deals with the bionomics and control of *Antestia.* Though reasonably complete in many respects, it shows that a great divergence of opinion, and but little exact information, exists concerning the actual part of the coffee plant on which *Antestia* feeds. Since this is closely connected with the amount of damage done it is clearly of primary importance and I intend to study the subject more fully on my return from leave. The chapter dealing with the natural enemies of *Antestia* includes, besides a summary of the information available relative to previously-known parasites, more detailed notes on a recently discovered Hymenopterous parasite. Part II consists of a detailed account of the life history of *Corioxenos antestiae* Blair (Strepsiptera) and Part III of the relations of this parasite with its host. Very little information concerning the biology of Strepsiptera has been obtained since the work of Nassonov nearly half a century ago, but, owing to the ease with which both host and parasite can be bred in the laboratory, it can be said that knowledge of the biology of *Corioxenos* is virtually complete.

I believe that a biological explanation has been found for the opposing views held on the merits of pyrethrum as a contact insecticide, and arsenic in a bait spray, for the artificial control of *Antestia.* Where most of the natural control is due to *Corioxenos* the bait spray has many advantages; where *Corioxenos* is absent and control is mainly performed by egg-parasites, pyrethrum is likely to be more effective.

I have also completed a short paper on colour vision in the first-stage larva of *Corioxenos.*

With the approval of the Secretary of State for the Colonies, facilities were given to Mr. B. Cooper to reside at the Station and work on entomological problems for six months from

March to September. Mr. Cooper studied the internal anatomy of *Corioxenos,* on which subject he has prepared a paper for publication.

Mr. D. Vesey-Fitzgerald, Government Entomologist to the Seychelles, spent some two months at the Station during the course of a visit to East Africa, the purpose of which was to search for natural enemies of Coconut scale-insects. He obtained, bred up and successfully despatched two species of *Chilocorus* (Coccinellidae), predators of *Ischnaspis longirostris,* the worst " hard " scale of the Seychelles coconut plantations. He also secured a species of *Exochomus* likely to be of value against *Lecanium tesselatum,* the most harmful " soft " scale.

T. W. KIRKPATRICK,
Entomologist.

REPORT OF THE SOIL CHEMIST.

In my last annual report I referred to a soil survey journey made in December-February, 1935-36, to the Lake Province of Tanganyika, passing on the way through parts of the Tanga, Eastern, Central and Western Provinces. The first half of the year under review was to a great extent taken up by work upon the material collected during that journey. A report was submitted in November, and took the form of a running commentary on the soils of the country seen in transit, linking together a series of essays upon the areas that had been studied more closely. The opportunity was taken to incorporate information that was already to hand for some parts of the route from material sent in to Amani by various district agricultural and other officers during the past few years. The report thus formed a summary of the knowledge gathered to the date of writing it, on soil genetics and soil distribution, on the relation of soils to vegetation, parent rock and topography, and on questions of soil utilization, in the regions it covered. The geographical scope of this work may be briefly indicated here by the chapter headings:—

Usambara foothills; Uzigua; Nguru foothills and scarp-foot; Mamboya (Kaguru foothills); Masai Steppe; Mpwapwa; Ugogo; Saranda-Manyoni-Kazi Kazi (the Rift Wall and the Uyansi plateau); Unyanyembe (Tabora); Kahama, including Tinde and Isaka; Shinyanga; Mwanza.

Amongst the topics dealt with were:—

The origin of the red earths of semi-arid country.

The proper use of small moist uplands surrounded by dry lowlands.

Rocky hillsides and knolls as soil factories.

The need for experimental soil surveys in typical semi-arid districts.

Soil types likely to yield an early return on measures of erosion-control.

The occurrence of *Brachystegia-Isoberlinia* woodland (" *miombo* ") and of " Itigi Thicket " in relation to soils.

Effects of slow denudation in the evolution of regional soil complexes.

Lime accumulations in termite heaps and the possibility they afford locally of cheap soil amelioration.

Problems in the advancement of native agriculture on poor sandy soils.

The increasing importance to native populations of solving the problems of *mbuga*-land utilization.

The mode of formation of subsoil ironstone.

Native soil nomenclature in Usukuma.

Hard-pan soils (grey pedocalic soils having an impervious alluvial clay horizon) and prospects in their utilization.

Soil survey and land-use planning, especially in relation to relief of over-grazed lands by reclamation from tsetse.

Parasitic weeds as affecting land occupation.

The dependence of native smallholders on two or more types of their local soil complex.

As a result of this review of the distribution and relationships of soil types in parts of Tanganyika, some emendation of the detail of the Provisional Soil Map has been shown to be necessary in certain localities, e.g., in Uzinza to the west of Smith Sound; but all my observations go to demonstrate the correctness of the general principles on which the map was drafted, especially the insistence on topographic complexes (" catenas ") as the only fair means of representing the soil pattern on a small scale in areas of regularly-repeated relief. It has been noted from recent soil literature that the catena as a unit of generalized soil description is receiving increasing acceptance and use.

One of the districts visited in January, 1936, Bukoba, was not dealt with in the report above mentioned, as laboratory work on its soils had not advanced far enough when the report was written. Further analyses are now to hand on the Bukoba soils and an account of the area on similar lines to that attempted for the other parts of the route is in preparation.

At the end of 1935 Mr. A. P. G. Michelmore, locust investigator on the staff of the Imperial Institute of Entomology, sent to Amani a collection of soil samples from the flood-plain that forms the non-permanent northern extension of Lake Rukwa. In connection with vegetation studies there he desired to know how far soil differences of a fundamental kind ought to be reckoned with, which might anchor the vegetation types in spite of cyclic changes in the flood regime. The samples have been worked on in the laboratory during the year, and

a fair understanding has been arrived at of the nature of soil parent materials on this flood-plain and the course of soil development according to the character, extent and duration of flooding. The results are of much general interest, and a report on them has been drafted, with a view to publication jointly with Mr. Michelmore's vegetation studies. To the particular ecological question that was put, the answer seems to be that on all the soils of *immature* development from the old lake-floor parent material (a volcanic ash deposit that has changed into a bentonite-like indurated white clay), the control of vegetation is not by intrinsic site properties due to soil, so much as by flood waters fresh or saline acting through reversible changes of labile soil properties such as reaction, salinity, proportions of exchangeable bases, aeration, temporary organic matter accumulation and the like. There are, however, also soils of *fairly mature* development in which far-reaching and irreversible changes have been undergone by the same parent material. On these the vegetation is not likely to respond so simply to the effects of the floods as they vary from year to year.

In this and other studies of the relation between soil and vegetation it has become evident how empirical at best are the correlations that can be effected in the complete absence of physiological data on the actual requirements or tolerances of the plants and tree species concerned. Ecological problems can be approached by the pedologist in ascertaining what the soil properties are and their tendencies in change, and by the field botanist in making floristic surveys and studying succession; but no causal relationships governing plant distribution are thereby established, and the subject is not in the end advanced very far until experimental methods can be introduced. Nor will really scientific solutions be reached until the botanists habitually work to a physiological classification of their plants as well as a morphological one.

Several soil profiles sent from a British-owned sisal estate near the coast fifty miles south of the Rovuma River in Portuguese East Africa were examined by special arrangement, although coming from outside the territories that the Station serves. They represent a very sandy soil type which, although prevalent along much of the East African coast, has up to the present been little studied. Advice was given by letter on certain specific points in the management of this soil, on which enquiry had been made.

A number of soil profiles from Oldeani, Ngorongoro, Mbulu, Kiru and Babati were received from Mr. H. B. Stent, Soil Chemist at the Coffee Research Station, Lyamungu. They represent soils occupied by European settlers in the volcanic region to the north-west of Lake Manyara and on the Basement Complex plateau further south, also a locality at the foot of the

Rift Wall and one on the slopes of the volcanic mountain Ufiume, all in north central Tanganyika. They have not been worked on except for cataloguing and preliminary examination.

Further examples of the soils of Kiboriani, the mountain mass above Mpwapwa, were received from Mr. R. R. Staples, Pasture Research Officer of the Veterinary Department of Tanganyika. They were taken in connection with his soil moisture studies under forest, *miombo* and grassland, and were reported on, with a discussion of the genetics of the soils in relation to these vegetation types, by letter in August.

During my visit of 1933 to the Iringa Province (now called the Southern Highlands Province) of Tanganyika, a programme of soil sampling was arranged with the Agricultural and Forest Officers, but was a good deal delayed by their other duties and by leave movements. Late in 1934, just before my own departure on leave, a very comprehensive collection of the soils of the European-farmed district of Dabaga was received, which had been made by the farmers themselves on the initiative of one of their number, Mr. G. C. Baker. The chemical work necessary for an understanding of these Dabaga soils has been largely completed this year, though some further sets of analyses remain to be done and the work is not yet ready for report. In the meantime representative samples from other parts of the Province have begun to reach Amani, collected by Mr. C. J. MacGregor, Agricultural Officer at Iheme, in fulfilment of the original programme. These also have had some attention and some of the necessary analyses are complete though others are still outstanding.

Since 1932, when I first visited the important areas of volcanic ash- and lava-derived soils around Kilimanjaro and Meru, analytical results and further samples and field data have been gradually accumulating. In 1934 I drafted an essay on the genetics and classification of these soils as a contribution to the proceedings of a soil congress that was to have been held at Barcelona in Spain. That congress was never held owing to political uncertainties, and publication of the paper was not proceeded with. Since then, the further information to hand has made possible the planning of a more complete treatment of the subject. With a view to this the area was revisited in January-February, 1937. By the courtesy of the Chief Scientific Officer of the Coffee Research Station at Lyamungu I was able to occupy quarters there for five weeks and make it a base for local travelling. Most of my attention however was devoted not to the European coffee estates of the middle belts of the mountain slopes, but to the native cultivations above, especially on Mt. Meru, and to the so-called maize belt on the lower slopes of Kilimanjaro, which is at present partly in native and partly

in European occupation but which still includes large areas of virgin or secondary *Combretum* bush and abandoned Ceara rubber estates.

Of recent years tsetse fly has invaded this belt, and the eviction of the fly (several species of *Glossina* are involved) is a problem to be faced if agriculture is to develop therein on mixed-farming lines, a trend the desirability of which the European farmers are very rightly insisting upon. While in that area I had the opportunity of studying the reports of the Director of Tsetse Research and several of his officers on the problems involved in getting rid of the fly, which inhabits not only the *Combretum* bush, the rubber, and the corridors of fringing forest that line the river courses and intersect the belt at intervals, but also the banana groves that everywhere are a feature of the Chagga cultivations. The campaign that has been proposed involves the establishment of a continuous belt of occupied land kept free for some years of all these kinds of cover, and one of the necessary conditions for its success is that the whole of the ground in the defined belt should be suitable either for arable cultivation or for conversion to treeless grassland. The case is one for an *ad hoc* soil survey, which I could not pretend to undertake in the time available.

I was however able to make some acquaintance with the soils at a number of places in the belt. Two of the three principal soil types, namely a deep brown clay loam (an excellent maize soil) and a heavy black clay which forms the floor of considerable stretches of mbuga, fall readily into place in the proposed scheme provided the difficulty can be overcome of inducing natives to occupy the brown soil without bananas and without irrigation water. There are however some large areas of rocky ground, at present under dense *Combretum* bush, where the soils are not only shallow but also of poor drainage; they offer very small inducement indeed to anybody to clear and occupy them. It may be that the desired cover-free belt can be delimited so as to exclude these rocky areas. In any case their existence demonstrates the need for including a fairly thorough reconnaissance of soils in the programme of preliminaries to the drafting of a clearance scheme of this kind, before actual commitments in it are undertaken.

The site of the proposed Cotton Experimental Station at Kahe was also visited. Here there is a deep brown alluvium, consisting of soil substance of volcanic origin transported from the Kilimanjaro slopes, and as regards morphology, texture and field properties generally it seems very suitable for the intended purpose, except for the numerous large termite heaps that dot the ground and which will enter seriously into the problems of experimental lay-out. Preliminary laboratory work has, however, shown the existence of some unsuspected

and large acidity differences between the several alluvial strata that make up the soil profile, so that again the need for a more careful study of the soils is indicated before commitments are definitely undertaken.

Two cases of partial crop failure have been investigated from the soil side in conjunction with officers of the Department of Agriculture, Tanganyika. One concerned a yellowing and death of coffee on a very raw volcanic ash soil; the investigation is not complete but so far has not brought out the cause of the trouble convincingly. The other concerned cotton on a very calcareous soil, also a volcanic ash in origin but having undergone at one time a phase of decomposition as a lake-floor deposit. Here excessive lime in the exchange-complex in proportion to potash and magnesia, and perhaps a deficiency of available iron and manganese, seem to be possible as causes of crop failure, and recommendations have been made accordingly.

Laboratory methods.

A good deal of progress has been made during the year in training the African laboratory hands to undertake those operations of soil analysis that can be reduced to a routine and governed by a definite set of simple instructions. As however all weighings of analytical accuracy, calculations and most operations requiring judgment have still to be done by the European, the limit of the extra output that can be achieved is soon reached, and it remains true that each year's work sees further accumulation of arrears of samples not yet examined analytically.

A beginning has been made with the assembly of apparatus suitable for the study of the water-stable aggregates in soils, in connection with projected work on the erodibility of various soil types. The measurement of soil colour by the spinning-disc method has been introduced and some progress made in a programme of collaborative work on this subject for the International Society of Soil Science. The better description of soil structure has also received attention and a series of reference specimens has been prepared from East African material for our guidance in keeping to a consistent nomenclature.

Publications.

The *Provisional Soil Map of East Africa* and its Memoir were received from the printers for distribution in May.

A " Note on Soil Conditions and Two East African Vegetation Types " appeared in the *Journal of Ecology*, January, 1937, and a letter on " Normal Erosion as a Factor in Soil Profile Development " in *Nature* of 26th September, 1936. Reviews and notes on soil subjects have been contributed to most of the issues of the *East African Agricultural Journal*.

A paper on " Soil Types and Soil Management in Relation to Plantation Agriculture in East Usambara " has been submitted for publication in that Journal, the first of a projected series of " Essays in Applied Pedology ".

The typescript Report on my Lake Province journey of December-February, 1935-6 was circulated to all the interested departments of Government in Tanganyika and to the other East African dependencies, and a copy is also being circulated in England by the Imperial Bureau of Soil Science. Several of the chapters of this report will in due course be re-drafted for publication when the laboratory data are more fully available.

My assistant Mr. W. E. Calton has taken a very full share in the work reported, especially being responsible for the bulk of the analytical work and for the training and supervision of the laboratory boys.

G. MILNE,
Soil Chemist.

REPORT OF THE BIOCHEMIST.

For nearly eight months out of the twelve under review I was absent on leave. The first three months of the period were fully occupied in bringing laboratory work on Derris and Mundulea to the stage where a number of papers could be written.

Whilst on leave I wrote up these results into the following five papers:—

1. Rotenone. Part I. The Determination of Rotenone.
2. Rotenone. Part II. Evaluation of Plants containing Rotenone.
3. The Evaluation of Derris and Mundulea.
4. *Mundulea suberosa* Benth. Part 2. Chemical Constituents.
5. *Mundulea suberosa* Benth. Part 3. Variability of Samples.

The first two are already published and the remainder are expeted to be published shortly. They describe a modified and improved method for determining rotenone in plants, and propose means for evaluating Derris and Mundulea by the method of determining optical rotation. The two papers on Mundulea, together with Part I of the series published in May, 1936, give all the available information that I have obtained for this plant.

Whilst on leave I found general agreement in London amongst both scientific workers and commercial interests that it would be a mistaken policy to allow low-grade Derris to be introduced into East Africa when the high-grade variety already established here was slowly becoming available. If Derris cultivation is to succeed in East Africa everything possible should

be done to prevent the industry from getting a name for poor quality. It must be borne in mind that in two or three years high-grade root will be coming on the market in quantity from Java and Malaya, and East African root must be able to compete with this.

Consequently, on hearing that *Derris malaccensis* and *D. elliptica* were being imported by planters into the Tanga district, I proposed to the Director of Amani that steps might be taken to prohibit the importation of *D. malaccensis* and low grade *D. elliptica*. The Imperial Institute was asked for advice on this matter, and I was present at meetings held there to consider the whole question. The importation of *D. malaccensis* into Kenya, Uganda and Tanganyika has now been prohibited.

Further work is now in progress on Derris and Mundulea; with the latter plant selection of good grade strains is now necessary, and several thousand grown from seed have been planted out. Before they become old enough for selection work I shall have to work out a more rapid and suitable method of testing them than is now available.

Most of my time during the coming year will be occupied with these insecticidal plants.

R. R. WORSLEY,
Biochemist.

REPORT OF THE PLANT PHYSIOLOGIST.

Coffee.

In my last annual report I outlined my studies of the stomatal movements of *C. arabica,* and suggested that stomatal control of photosynthesis might be effective in this species.

I have since been able to study this problem in the field. Results show that the march of apparent assimilation in coffee leaves is exactly that demanded by hypothesis. A full account has been accepted for publication in the *Annals of Botany*. A second paper collating the results of work on stomatal behaviour of coffee is awaiting publication. Sunshine of an intensity greater than about 0·7 gm. cals./cm^2/min. causes stomatal closure in *C. arabica,* and depresses assimilation. During sunny weather the daily carbohydrate income of an unshaded horizontal coffee leaf is very low indeed; whereas under shade it is greatly increased. This fact may have considerable practical bearing on policy in the use of shade.

I would emphasize that these results are from horizontal leaves only. While it is probable that the march of apparent assimilation of a whole coffee tree will be somewhat similar, it is also probable that the effects of sunshine on the tree will be less marked than on the single leaf. The diverse positions assumed by the leaves, and the considerable proportion shaded by others, should always permit of appreciable photosynthesis by the tree as a whole, whatever the altitude of the sun.

The next step in this research is the measurement of the march of assimilation of whole trees under field conditions. Success will depend on the development of suitable apparatus, and I hope to be able to design this during my next leave. If I am successful, work should start in the field in 1938.

I have also started to investigate the stomatal behaviour and the march of assimilation of *C. robusta*. Results obtained so far, while not quite conclusive, indicate that stomatal movements in *C. robusta* differ considerably from those in *C. arabica*.

Sisal.

Little work on sisal has been possible this year, since coffee investigations occupied most of my time. I have started work on the water-relations of the plant, and hope to investigate other aspects of its physiology in due course.

Miscellaneous.

In collaboration with the Biochemist of the Kenya Coffee Board I investigated methods of tree-injection during a visit to Lyamungu. We found that it is sometimes possible to confine treatments to a portion of the tree, which can then be used as a " plot ". This has enabled Dr. Case to investigate the effects of certain elements on " quality ", but the method has proved to be unsuitable for work on the problems on which I am engaged.

I have written articles for the *East African Agricultural Journal* on sisal grading, on *Agave* fibres, and on physiological research as applied to coffee.

The expected appointment of a second physiologist should ensure continuity, which has been hitherto lacking. It should thus increase the scope of physiological work at Amani, as well as its volume.

F. J. NUTMAN,
Plant Physiologist.

REPORT OF THE GENETICIST.

Agave.

General.—With new accessions from various sources in America and gifts from Colonel the Hon. M. T. Boscawen, 88 species and varieties of *Agave* are now represented in our collection. Records of the development of all this material have been maintained and leaf counts made at intervals of two months throughout the year. Families of vegetatively propagated *Agave sisalana* were cut for the first time in August, 1936. A paper on the vegetative development of these families in relation to yield is being prepared.

Sisal v. *Blue Sisal.*—The comparative trial plots of *A. sisalana* and *A. amaniensis* were cut for the first time in April, 1936. Planted in March, 1933, the trial compares the development and yield of blue sisal suckers and common sisal bulbils. There are six plots of each variety and twelve plants in each plot. The mean values for number of leaves cut, weight of leaf cut, and yield of fibre (extracted) do not show any significant differences. The blue sisal plots however produced longer leaf than the sisal plots. The yield of fibre for blue sisal and sisal was equivalent to 2 to $2\frac{1}{2}$ tons per acre; the density of plants is about 2,000 per acre.

Seedlings and hybrids.—A first cut was also taken from the F 1 generation of the cross *A. angustifolia* × *A. sisalana.* Seed from this cross was sown in July, 1931, and 235 young plants were transferred to the field in October, 1932. Some of these plants were ready to cut in 1935, but cutting was delayed until my return from leave. Nine plants gave a yield of more than 100 lb. of leaf, a very satisfactory figure. The number of leaves actually cut from these plants varies between 75 and 181 out of a total production of 193-312 leaves, which may be compared with an average of between 40 and 50 leaves cut per plant from sisal (bulbil) plants of about the same age. There is however a wide range in the leaf length and average weight of leaf amongst these nine plants: 6·75 to 13·9 dcm. in length and 0·595 to 1·67 lb. per leaf in weight.

Four plants of this family have poled; only one of these is included amongst the highest yielders. Two plants have produced 221 leaves, one 232 leaves and one, a high yielder, one of the nine best plants, 316 leaves. Suckers of *A. sisalana* planted in May, 1931, have produced at the time of poling between 190 and 227 leaves. Some seedling plants of *A. sisalana* grown from seed in 1929 and planted in the field in April, 1931, have also poled. The greatest total number of leaves produced by any one of these seedlings is 260, the next best being a total of 248 leaves. Of the eight other plants of this family now poling, none has exceeded 200 leaves per plant. None of these plants has formed fruits.

In view of this demonstrated variability in seedlings of *A. sisalana,* each plant must be treated as unique. In the early tests therefore, it is impossible to decide to what extent the differences in development are due to genetical factors and to what extent to environmental factors. This can be done only when the individual plants can be multiplied vegetatively. As soon therefore as bulbils can be obtained from selected plants, further comparative trials in progeny rows will be instituted. A similar procedure will be followed with the F 1 plants from the *A. angustifolia* × *A. sisalana* cross.

Most of the seedlings and seedling hybrids raised last year have been transferred to the Sisal Experiment Station, Ngomeni Seedling plants of *A. amaniensis* and *A. fortunae* and the hybrids (1) *A. amaniensis* × *A. angustifolia* and (2) *A. angustifolia* × *A. amaniensis* now occupy an area of one hectare on that Station. Some 3,000 plants of the cross (2) above, were raised and one-third only of these were sent to Ngomeni. Of the balance all forms having a spineless leaf margin have been planted at Sigi and the remainder, the spiny margin forms, discarded. Two hundred seedlings from the cross *A. amaniensis* × *A. sisalana* will shortly be transferred to Ngomeni.

The following new crosses have been made:—

(1) *A. amaniensis* (2x) × *A. cantala* (3x).
(2) *A. angustifolia* (2x) × *A. cantala* (3x).
(3) *A. angustifolia* (2x) × (*angustifolia* × *sisalana*) F 1, No. 56.
(2x) (5x)
(4) *A. angustifolia* × (*angustifolia* × *sisalana*) F 1, No. 78.
(5) *A. angustifolia* × *A. sp.* (*lespinassei* ?) (2x).

The figures in brackets indicate the chromosomal constitution of the species; x, the basic number, is 30.

Crosses Nos. 2-4 have given a fair set of fruits, No. 1 very few and No. 5 a very good set. The fruits will not be ripe until June, 1937.

Cytology.—A paper on the cytology of seven species of fibre *Agave* has been published (*J. Genet.*, 1936: 33). Cytological studies have been continued. Counts of somatic chromosome numbers have been made for some seedlings of *A. sisalana* and also in a few cases studies of meiosis in the same material. Meiosis has also been studied in the hybrid *A. angustifolia* × *A. sisalana* and in *A. lespinassei* and *A. Sartorii.*

Coffee.

With the exception of plants which have been used as parents for selfing and in crosses, plots of *C. arabica* established in 1928 have been uprooted and the area replanted with *C. robusta,* the progeny of selected parents. Cuttings of the parental *arabica* plants have been taken for propagation at the Coffee Research Station, Lyamungu.

Yield.—Yield records covering the period 1930-6 for the families of *C. arabica* raised from seed of selected parent plants (open pollinated) show a very wide range of variability in yield. From a general survey of the data it is obvious that a great deal of the variability is due to positional effects, but the irregular stand of the surviving trees does not permit an accurate analysis of this influence. There are also differences in the

time between planting in the field and production of the first crop for different trees. When trees are grouped to the number of seasons in which they bore a crop and the *total* yields per tree considered, the standard deviation of the yield of a single tree in many groups is greater than the mean yield per tree.

As early as 1931, the second cropping season, certain trees were selected for selfing. The characters on which selection was based were general development and vegetative vigour, freedom from leaf disease and the type of bush. All but one of these trees have proved to be amongst the highest yielders in the plots as a whole. The highest yielding trees, irrespective of origin, lie in a narrow belt running down one side of the plots, where apparently conditions are more suitable for the development of *C. arabica.*

Plants of four families grown from selfed seed from these selected parents have borne a crop for the second time this season. The variability in yield of these plants is very high, the coefficient of variability being in excess of 100 per cent. for one family of twenty-nine plants. Two other inbred families (F1.) of *C. arabica,* one of twelve plants and the other of ten plants, give coefficients of variability of 43·6 per cent. and 58·4 per cent. for two seasons' cropping. If yield is determined genetically by the interactions of a number of factors and these factors are all influenced in their expression by environmental circumstances, cultural and natural, improvement in the yielding capacity of Arabica through breeding is certain to be a laborious, and probably an unprofitable, proceeding. Selection and vegetative propagation of plants already possessing the desired combination of factors offers much more hope of success in a reasonable time.

Three F2. families of inbred Arabica have been planted in the field and are making fair progress.

Grafted Plants.—Scions of Arabica, obtained from unselected seedling material, grafted on to seedling Robusta stocks, have given a much lower yield in 1936 than in previous years but promise a heavy crop in 1937. The combined yields for seasons 1934-6 for plants inarched as seedlings give a mean yield of 3,663 grammes of cherry per plant with a coefficient of variability of 59·2 per cent. Five plants grafted as yearlings on to Liberica stocks have given a mean yield of 11·8 kg. cherry per tree over the same period, with a coefficient of variability of 29·7 per cent.

C. robusta *Selection.*—All *C. robusta* plants with the exception of those selected for further propagation have been stumped; the selected plants will be grafted on to these stumps. The variability in yield of Robusta coffees from tree to tree is comparable with that of Arabica coffee. The regular stand in the Robusta plots permits an analysis of the positional influence on yield. The reduction in variance due to error obtained by

eliminating positional effects is about 40 per cent., but the coefficient of variability still remains high at 50-60 per cent. Yield records for the Robusta varieties cover the period 1932-6.

Plants grown from seed of parents (Nganda type) selected by the Department of Agriculture, Uganda, have been planted in the field.

Breeding.—Some three hundred plants have been raised from seed of the F1. *C. arabica* x *robusta,* after open pollination. Some seed from this cross has also been sent to the Scott Agricultural Laboratories, Kenya, and to Lyamungu. Most of the fruits collected contain abortive seeds. A much smaller set of fruits has followed the stumping of the adjacent Arabica plants this season, confirming the conclusion arrived at from cytological examination of root tips of the F2. plants that *C. arabica* was the principal pollinating agent.

Hybrids between varieties of *C. arabica* being grown at Lyamungu have made fair progress during the year. One family, a cross between *C. arabica* var. *maragogipe* and *C. arabica* var. *" Java ",* was forced into flower in October, 1936, by watering, before any other coffee was in flower.

C. eugenioides has been crossed with *C. robusta* and the cross *C. arabica* x *C. eugenioides* has also been made apparently with success.

Quality.—Twenty-five samples of coffee for liquoring tests have been forwarded to the Imperial Institute. A report on the results of tests over the period 1931-5 has been prepared. Copies of this report have been sent to the Departments of Agriculture concerned and to the Imperial Institute and the brokers, Messrs. J. K. Gilliatt, responsible for the tests, for their comments before publication. Suggestions for further work have been put forward; but in view of the fact that problems connected with quality in coffee are being studied by the Biochemist appointed by the Coffee Board of Kenya, the continuance of the investigations by Amani may be considered redundant.

Cytology.—Cytological investigations on *Coffea* species have given some interesting results. The somatic chromosome numbers of six species and varieties not previously recorded have been determined.

Species.	*Somatic Chromosomes (2n).*
1. *C. mufindiensis*	22
2. *C. sp.* (ex Moçambique)	22
3. *C. travancorensis*	22
4. *C. eugenioides*	22
5. *C. stenophylla*	22
6. *C. arabica* var. *amphillo* (ex Abyssinia)	44

A somatic number of 2n = 44 has been determined for two plants surviving in a plot labelled *C. arabica-liberica* hybrids, at Sigi. One of these plants produces a yellow cherry; both produce a high proportion of abortive seeds.

Meiosis has been studied in several plants of the *C. arabica* × *robusta* hybrids. Trivalents, bivalents and univalents are formed at first metaphase and the meiotic divisions result in a high proportion of sterile gametes. From limited observations made on *C. arabica,* meiosis appears to proceed regularly following the formation of 22 bivalents, with one to two chiasmata per bivalent. The species appears to be an allopolyploid. The relationship between *C. arabica* and *C. robusta* is not yet clear. Geographically, the limits of the areas occupied by the two species are not widely separated. The occurrence of trivalents, bivalents and usually only five to eight univalents at meiosis in the triploid hybrid *C. arabica* × *robusta* indicates a certain degree of homology between *C. robusta* and *arabica* chromosomes and also between chromosomes of the haploid complement of *C. arabica* chromosomes. A full interpretation of the phenomena observed is not yet possible. Endeavours to induce the somatic doubling of the chromosome complement by encouraging the development of shoots from callus tissue have not yet met with any success. Two plants raised in the F. 2 generation from this cross have 55 chromosomes; probably they originated by the union of an unreduced gamete in the hybrid and a normal gamete of *C. arabica.* Pollination of the hybrid with pollen of the Robusta parent does not appear to have been successful.

General.

Travelling during the year has been restricted to visits to sisal estates in the Tanga Province, the Sisal Experiment Station, Ngomeni and one visit to the Coffee Research and Experimental Station, Lyamungu.

I have maintained contact by correspondence with officers of the Departments of Agriculture in Kenya, Tanganyika and Uganda with reference to coffee problems and can record the closest co-operation with the officer in charge of the Sisal Experiment Station.

L. R. DOUGHTY,
Geneticist.

REPORT OF THE SYSTEMATIC BOTANIST.

Herbarium.

During the year a total of 2,684 determinations was made on specimens received for naming, and information was supplied to a wide range of institutions and workers in East Africa and other countries.

The Herbarium equipment was supplemented by the addition of eight small units of herbarium cases, which enabled me, to a certain extent, to reduce the very overcrowded condition. With a rapidly expanding herbarium lack of space for further cases is becoming a major problem; it is hoped that more space will be provided by the construction of a building more suitable than the existing one.

The following papers have been prepared:—

" Mundulea Fish Poison ", *Bull. Misc. Inf. Kew,* 1936, pp. 3-8.

" A Note on Longido and Ketumbeine Mountains ", in collaboration with R. E. Moreau, to be published in *Tanganyika Notes and Records.*

" Artificially Induced Lactation in Humans ", *The East African Medical Journal,* February, 1937.

" A Swahili Dictionary of Plant Names ", to be published by the Government Printer, Dar es Salaam.

Type Species.

In the course of revising a " Check List of Trees and Shrubs of Tanganyika Territory " for the Imperial Forestry Institute, and whilst determining specimens for various departments and individuals, a further sixty-five isotypes were discovered in the Herbarium.

The following new species have also been described from the Herbarium:—

Abutilon Braunii E. G. Baker in *Journ. Bot.,* 74: 193 (1936). Malvaceae. Tanganyika Territory; Usambaras, Mombo steppe. 6th August, 1908, *Braun* 1927, type, 1928.

Agrostis Uhligii C. E. Hubbard in *Kew Bull.,* 1936, p. 309. Gramineae. Tanganyika Territory; Mt. Meru, 3480-3780m. *Uhlig* 610, type, 1068.

Agrostis Uhligii C. E. Hubbard var. *contracta* C. E. Hubbard, l.c. p. 310, Gramineae. Tanganyika Territory; Mt. Kilimanjaro, foot of Kibo, 4800m. *Uhlig* 71, type, 3000m. *Grote* 6320; Mt. Meru, 3780m. *Uhlig* 613 in part.

Agrostis tricholemma C. E. Hubbard, l.c. p. 304. Gramineae. Tanganyika Territory: Iringa Province, Msima Stock Farm, in vleis, *Emson* 359, type.

Helictotrichon phaneroneuron C. E. Hubbard, l.c. p. 332. Tanganyika Territory; Iringa Province, Msima Stock Farm, common in vleis, *Emson* 348, type; E. Ubena, Ukinga-Upanga, *Hill* H3/30/27.

These new species bring the total number of type specimens recorded in the Amani Herbarium up to 305 isotypes.

Contributions.

Seventy-six contributions were received, a total of 3,602 specimens, the bulk having been sent for identification. They were received from the following institutions and individuals:—

The Department of Veterinary Science and Animal Husbandry, Tanganyika Territory, collected by Messrs. Emson, Hornby and Staples	383
The Amani Staff	439
The Department of Agriculture, Zanzibar	9
The Department of Agriculture, Tanganyika Territory, collected by Messrs. Cairns, Davies, Eyre, Gillman, Haarer, Harris, McGregor, Rounce and Ward	1,562
R. G. Turrall, Esq., Nairobi, Kenya Colony	90
The Medical Department, Laboratory Service, Tanganyika Territory	4
The Forest Department, Tanganyika Territory, collected by Messrs. Fletcher, Grant and Pitt-Schenkel	41
H. Koritschoner, Esq., Makuyuni, Tanganyika Territory	71
The Royal Botanic Gardens, Kew ...	180
The Tsetse Research Department, Tanganyika Territory, collected by Messrs. Moggridge and Swynnerton	442
The Imperial Forestry Institute, Oxford	170
B. Leechman, Esq., D.O., Same, Tanganyika Territory	47
D. V. Fitzgerald, Esq., Department of Agriculture, Seychelles	35
Mrs. J. Fosbrooke, Loliondo, Masai District, Tanganyika Territory	28
Minor contributions from East Africa ...	10
Total received	3,511

Exchanges of botanical material.

Named botanical material was distributed to the following institutions and individuals:—

The Royal Botanic Gardens, Kew ...	1,358
The Botany Department, British Museum	216
The National Herbarium, Pretoria, South Africa	615
The Analytical Chemist, Medical Department, Tanganyika Territory	4
The Imperial Forestry Institute, Oxford ...	408
The Tsetse Research Department, Tanganyika Territory	300
D. Gillett, Esq., Achimota College, Gold Coast	42
The Berlin Botanic Gardens, Berlin ...	120
Miscellaneous institutions and individuals	7
Total distributed	3,070

Loans.

Specimens were loaned from the Herbarium to the following institutions and individuals:—

The Royal Botanic Gardens, Kew (132 sheets Acanthaceae, Gramineae and Orchidaceae, 3 returned); The Botany Department, British Museum (54 sheets of *Combretum* and Filices); E. G. Baker, Esq., c/o British Museum (194 sheets Malvaceae, 34 returned); The Imperial Forestry Institute, Oxford (29 sheets of *Brachystegia,* etc.); Prof. E. B. Babcock, University of California, Berkeley, California (11 sheets *Crepis* spp.); W. V. Harris, Esq., Department of Agriculture, Tanganyika Territory (11 sheets of Malvaceae and Sterculiaceae); and J. B. Hutchinson, Esq., Institute of Plant Industry, Indore, Central India (8 sheets *Gossypium* spp., returned).

Field Work.

No new botanically unexplored areas have been visited. Collections of the local forest and grassland flora, with ecological and economic notes, were continued and some new and little-known trees were discovered. Several visits were paid to the coastal districts between Pangani and Moa to gain some knowledge of the coastal vegetation. Extensions to the geographical range of some Kenya coastal tree species were discovered and it is proposed to make frequent visits to these areas to obtain a more detailed knowledge of the vegetation which is rapidly being changed by native and European cultivation.

From time to time the different species and vegetational types of the local and coastal vegetation were demonstrated to the following official visitors: Mr. R. R. Staples, Pasture Research Officer, Department of Veterinary Science and Animal Husbandry, Tanganyika Territory; Mr. C. F. M. Swynnerton, Director of Tsetse Research, Tanganyika Territory; Mr. D. V. Fitzgerald, Entomologist, Department of Agriculture, Seychelles; Mr. J. C. Stewart, Minaki, Tanganyika Territory; and Mr. H. J. Lindeman, Education Department, Tanganyika Territory.

P. J. GREENWAY,
Systematic Botanist.

ORNITHOLOGICAL WORK.

During my leave, from April to November, I spent several weeks at work in the British Museum (Natural History) in connection with material collected in East Africa during the tour. I received much kindness and assistance from Mr. N. B. Kinnear, Captain C. H. B. Grant and the staff of the Bird Room. My conclusions on certain of the species I reviewed, viz., *Thripias namaquus, Mesopicos griseocephalus, Arizelocichla chlorigula, Phyllastrephus fischeri, Chloropetella holochlorus, Dioptrornis fischeri,* are appearing in the *Bull. Brit. Orn. Club,* Vol. 57.

During the year one new form has been described from our collections:—

> TURDIDAE.—*Bessonornis macclounii mbuluensis* Grant and Mackworth-Praed (*Bull. Brit. Orn. Club,* Vol. 57, p. 80).

While in England I read a paper on "Breeding Seasons of Birds in East African Evergreen Forest", since published in the *Proc. Zool. Soc. London,* 1936, pp. 631-53. It is a striking fact that in the equable climate and fully evergreen conditions of Amani the breeding of most of the species comprising the forest bird community is confined to one season of the year, about September to February. No acceptable explanation can at present be put forward. There are indications that in other evergreen forests in the African and American tropics a defined breeding season is the rule, but its relation to temperature and rainfall curves varies with the locality.

Progress during the year with the faunistic work sponsored by the British Museum has been practically confined to Tanganyika Masailand, an imperfectly known area in which most of the island forests have not previously been examined. Thanks to the collaboration of Mr. E. G. Rowe the avifaunae of several of them are fairly well known.

At Mkomasi a subsidiary study begun in 1934, on the population of *Euplestes nigroventris*, a weaver-bird, showed promise of interesting results. "Territory holding" and polygamy were found to be developed in an extreme form and there was a probability of genetical sex-disproportion. Unfortunately I shall not be able to pursue the subject as I had hoped. The spread of cultivation has interfered with the exceptionably favourable area which I was to keep under observation for several seasons; and the sexing of nestlings, which would have settled the question of sex-disproportion, has baffled a succession of accomplished microtomists in the United Kingdom.

Observations made during the years 1933-6 on *Bycanistes cristatus* have been combined with data on *Lophoceros* spp., to which Mr. S. A. Child made a most valuable contribution, and published under the title "The Breeding Biology of certain East African Hornbills" (*J. E. Afr. Uganda Nat. Hist. Soc.*, Vol. 13, pp. 1-28, 1936). The Deutsche Ornithologische Gesellschaft are requesting permission to print a translation in their Journal.

The whole subject of hornbill nesting forms a remarkable chapter in vertebrate biology which is very imperfectly documented. While in England I collected the scattered references in literature and prepared a paper on "The Comparative Breeding Biology of the African Hornbills", which has been accepted for publication by the Zoological Society of London. Specific and generic differences in habits are found to be altogether more marked than had been suspected.

Since my return I have had exceptional opportunities for filling certain of the gaps left in these studies, because several nests have been available locally for observation and moreover at considerable trouble to herself Mrs. Moreau has brought up nestlings of both *Bycanistes cristatus* and *Lophoceros melanoleucos*. The technique of plastering by the latter, when barely half fledged, has been observed in detail. Curves of feather-growth in the two species show an interesting difference.

Sustained observations on hornbills' nests by African observers have also accumulated much data bearing on the question of the degree of individuality shown by birds and their utilization of available food. I take the opportunity of recording that local Africans, selected, but apparently of no particular mental attainments and able only just to read and write, Swahili, have shown themselves apt, reliable and keen observers, whose notes written in the field are of permanent value. At this stage of African development it is possible, as other departments are doubtless finding, to obtain masses of useful routine biological data very cheaply.

Migrant birds from Europe and Asia form an important element of the African fauna during six months in the year.

Partly in consequence of a request from the British Ornithological Trust for information on the habits of migrants in their winter quarters, and partly because for Tanganyika, unlike the other African territories, no up-to-date avifaunal list is in existence, I have made a compilation of the existing published records of migrants together with my own notes. One hundred and nine Palaearctic forms can be admitted with certainty to the Tanganyika list, but as yet too little is known of their ecology and geographical distribution while they are in the country. In a paper that will appear in *Tanganyika Notes and Records* under the title " Migrant Birds in Tanganyika " I have also included migrants between Africa and Madagascar and the long-distance intra-African migrants. Of the latter one important element is composed of species breeding on the edge of the Sahara during the rains and then coming south. Another is formed by several species of parasitic cuckoos, the movements of which are still obscure. I find that certain of them, unlike the European cuckoo, call extensively when not in breeding condition. In an attempt to elucidate their local status it is therefore especially important that the gonads of any specimens collected should be examined.

During the return voyage from England an exceptionally large number of land birds were observed at sea. The records obtained point to certain general conclusions and in particular provide evidence of a migration, hitherto hardly suspected, across the Arabian Sea. Any observations of birds at sea between Mombasa and Guardafui are of sufficient interest to be communicated, especially if the ship's noon position can be quoted.

R. E. MOREAU.

REPORT OF THE SUPERINTENDENT OF PLANTATIONS.

The work on the development of the Kwamkoro Estate has occupied a considerable part of the activities of the Superintendent and the Amani nursery staff during the year.

The distribution of plants and seeds has again increased. This was no doubt due to the publication of the Amani Plant and Seed List in the *East African Agricultural Journal.* The growing and collecting of material for the Biochemist's investigations of insecticides and essential oils has been continued.

Observations and work on crops, under their separate headings are as follows:—

Kwamkoro Estate.

Tung Oil trees.—Fifty-eight acres of *Aleurites montana* were planted during the year, making a total of 108 acres. Plants planted during 1935 still promise well. Approximately 20 per

cent. loss occurred in the 1936 planting. This was due to the failure of the September-December rains and the exceptionally dry period from January to the end of March.

Cinchona.—Twenty-eight thousand *Cinchona ledgeriana* and 10,500 *C. succirubra* plants were planted during the year. At present the *C. ledgeriana* plantings are growing more vigorously than *C. succirubra.* This would appear to be due to the *C. ledgeriana* having withstood the unusually dry period better than *C. succirubra.*

In the nurseries 14,000 *C. ledgeriana,* 5,000 *C. succirubra* and 24,000 *C.* hybrid seedlings have been planted. The transplanting of the seedlings from Amani into the Kwamkoro plantation nursery beds continues.

Coffea robusta.—The planting up of the selected *Coffea robusta* plants in the Mlesa area has been completed. Plots near the factory have also been extended. The total area now planted with *Coffea robusta* is approximately 100 acres.

With the exception of a ten-acre plot, to be grown under an intensive culture system, no further plantings are anticipated. The balance of seedling plants in the nursery (some 40,000) will be sold to planters.

Grafted Coffea arabica.—A ten-acre plot has been prepared for planting with *C. arabica* inarched on *C. robusta* stocks. The planting of five acres of this is completed. Sufficient plants to complete the plot have been grafted in the Amani nursery and will be planted during the coming rains. For comparative purposes every tenth row has been planted with *C. arabica* on its own root system.

Tuba Root.—Derris elliptica plants planted in 1935 continue to do well. A further 5,500 plants have been planted. Twenty thousand cuttings have been taken and are being rooted in the Amani nursery for the extension of the Derris plots during the year.

General.—No work was done on the old *C. arabica* plantations with the exception of cleaning through with bush-knives to facilitate the picking of the crop. Three tons of parchment *Coffea arabica* and two and a half tons of clean *C. robusta* were harvested.

Livestock.—At the beginning of the year there were 141 head of stock. Thirty-three calves were born and two animals were received from the Tsetse Research Department. Eleven calves and two cows have died. Fourteen animals have been fly-struck. Injections with Antimosan and later with Surfen " C " have proved effective, only two cows dying from this disease. Five calves died soon after birth; of the other deaths among the calves, five are suspected to be East Coast Fever. The Amani cattle are sprayed with cattle-dip weekly; the Kwamkoro stock have remained free from ticks.

Amani Plantations and Nurseries.

Tung Oil.—Five thousand plants of *Aleurites montana* were raised during the year. Most of these have been planted at Kwamkoro. A few plants were supplied to the Agricultural Officer, Lushoto, for trial at the various altitudes in the Western Usambaras.

The original trees in the nursery and a few in the Station grounds are again fruiting well. It is estimated that some 50 lb. of seed will be available for distribution to Agricultural Departments. A considerable amount of damage was done to last season's crop by rats. It was even found necessary after planting to protect the seeds from being taken by this pest.

Forty plants of *Aleurites Fordii,* raised from seed collected from the Amani trees, were planted in the Station grounds. A few seeds of this species will be available for distribution this year.

Tuba Root.—Five thousand five hundred plants of *Derris elliptica* were supplied for planting at Kwamkoro. A further 6,000 are ready for planting, while 14,000 cuttings are being rooted in nursery beds.

Distribution of Derris planting material this year to the Agricultural Departments has been arranged.

Varieties of *Derris elliptica* from Ceylon, Singapore, and Seychelles, and *Derris malaccensis* have been added to the nursery collection.

Mundulea Bark.—Three thousand five hundred plants of *Mundulea sericea* (*suberosa*) have been planted out in the Sigi area for investigational purposes by the Biochemist. These plants have been raised from seeds collected in the Moa (Tanga) area, Sindeni (Korogwe) area and Zanzibar.

Cinchona.—The raising of *Cinchona ledgeriana, C. succirubra* and *C.* hybrid seedlings for planting at Kwamkoro has been continued. An unusually large quantity of both *C. succirubra* and *C.* hybrid seed has been distributed.

Owing to the failure of *C. ledgeriana* trees to flower this year, there has been an acute shortage of seed, the quantity available not being sufficient for our own requirements.

Coffea.—The inarching of one-year-old *Coffea arabica* on *C. robusta* stocks for the ten-acre experimental plot at Kwamkoro is now complete.

Boehmeria nivea (Ramie).—The demand for this plant has considerably decreased; 5 cwt. of root divisions only were distributed during the year.

Sisal.—Sixteen thousand suckers and 90,000 bulbils of "Blue Sisal", *Agave amaniensis,* were distributed during the year. Approximately 300 plants are now poling and it is estimated that over 200,000 bulbils will later be available for distribution.

The following plants have been grown from seed for the Geneticist and transferred to the Sisal Experimental Station, Mlingano:—

	Plants.
Agave amaniensis seedlings	928
A. amaniensis × *A. angustifolia*	164
A. angustifolia × *A. amaniensis*	1,043
A. fortunae seedlings (open pollinated seed received from La Mortola	1,145

Other *Agave* species sent to the Sisal Experiment Station include:—

	Plants.
Agave nirvana	12
A. sisalana. Capt. T. 1	6
A. sisalana. Capt. T. 2	12
A. miradorensis. Capt. T.N. 1	8
A. fourcroydes. Mexico	11
A. rigida. La Mortola	16
A. Sartorii	20
A. fourcroydes var. fol.	2
	Suckers.
A. cantala	500

Native Food Plants.—A collection of "Yams", *Dioscorea* spp., has been planted for trial and eventual distribution of planting material to the Agricultural Departments. Eleven varieties were imported from Ceylon; the remainder collected locally by Agricultural Officers throughout the Territory.

Plant Quarantine.

Importations through the Plant Quarantine:—

Sugar Cane Varieties—

Mayaguez, 28.
CO, 312.
CO, 244.
CO, 285.
Kavingiri.
Yellow Caledonia.
Badila.
Diamond, 10.
P.O.J., 2,747.
D, 625 (did not survive).

Succulent Plants.—3 collections (105 plants).

Orchids—2 collections (42 plants).

Plant and Seed Importation.

Eighty packets of seeds, 60 miscellaneous plants, 48 cuttings, 21 *Dioscorea* spp., and 1 lb. of *Mundulea suberosa* seed were imported during the year.

Plant and Seed Distribution.

Five hundred *Casuarina equisetifolia* plants, 451 miscellaneous plants, 296 packets of seeds, 580 cuttings, 16,057 *Agave amaniensis* suckers, 500 *A. cantala* suckers, 89,962 *A. amaniensis* bulbils, 4,520 sugar cane cuttings, 506 Uba cane cuttings, 5 cwt. Ramie root divisions, 70½ oz. *Cinchona* hybrid seed, 29 oz. *Cinchona succirubra* seed, 2 oz. *Cinchona robusta* seed, 1 oz. *Cinchona ledgeriana* seed, 50 lb. *Maesopsis Eminii* seed, 35 lb. *Hevea brasiliensis* seed, 30 lb. Kapok seed, 24½ lb. *Coffea robusta* seed, 10 lb. *Coffea arabica* seed, 21 lb. *Allanblackia Stuhlmannii* seed, 4½ lb. *Cedrela odorata* seed, 3 lb. *Telfairia pedata* seed, 2 lb. Cacao seed, 2 lb. *Raphia pedunculata* seed, 2 lb. *Musa textilis* seed, 1 lb. Tea seed, 1 lb. *Aleurites montana* seed, 1 lb. *Aberia caffra* seed, 1 lb. *Grevillea robusta* seed, 1 lb. *Eucalyptus maculata* var. *citriodora* seed, 1 lb. *Acacia decurrens* seed, ½ lb. *Pithecolobium saman* seed, ½ lb. *Albizzia stipulata* seed, ½ lb. *Anona squamosa* seed, ¼ lb. *Elettaria cardamomum* seed, 10 lb. Ginger rhizomes and 48 miscellaneous bulbs.

F. M. ROGERS,
Superintendent of Plantations.

REPORT OF THE SECRETARY AND LIBRARIAN.

During my absence on leave Mr. Nutter was in charge of the office and library. The causes of increase in work mentioned in my last annual report have intensified during the year. The fact that the *East African Agricultural Journal* is edited from Amani makes special calls on the time of the office staff. Library indexing has suffered. A reorganization of work which is in hand will, I hope, help matters.

The whole of the maintenance of the Library is now being met from the income of the Carnegie Trust Fund. Apart from periodicals and pamphlets fifty-nine volumes were added during the year.

R. E. MOREAU,
Secretary and Librarian.

APPENDIX A.

FINANCIAL STATEMENT FOR THE YEAR ENDED 31st DECEMBER, 1936. EAST AFRICAN AGRICULTURAL RESEARCH STATION.

Revenue.

Ordinary Recurrent Revenue:—

	£
H.M. (Imperial) Treasury	6,000
Contribution, Tanganyika Territory	6,000
Contribution, Uganda	1,800
Contribution, Kenya	1,700
Contribution, Zanzibar	1,200
Contribution, Northern Rhodesia	300
Contribution, Nyasaland	300
	17,300
Local Sales, etc.	398
Total	17,698

Maintenance Expenditure.

	£	£
Personal Emoluments	11,002	
Passages	702	
Pensions Contributions	1,841	
Laboratories	875	
Library	14*	
Publications	285	
Office Telephones and Contingencies	199	
Materials	505	
Freight and Transport	260	
Travelling	608	
Labour	1,242	
Total maintenance expenditure		17,533

	£
Saving on the year's maintenance (due to non-appointment of Director)	165

Capital Expenditure.

	£	£
Hydro-electric plant	1,226	
Electrical renewals	7	
Total		1,233

* The maintenance of the Library was borne almost wholly by the Carnegie Trust Fund.

Summary.

	£	£
Recurrent Revenue	17,698	
Reserve on 1st January, 1936	2,974	
Transfer from Kwamkoro Reserve	250	
		20,922
Maintenance expenditure	17,533	
Capital expenditure	1,233	
		18,766
Reserve on 31st December, 1936		2,156

APPENDIX B.

LIST OF PUBLICATIONS DISTRIBUTED UP TO 31st MARCH, 1936, BY THE EAST AFRICAN AGRICULTURAL RESEARCH STATION.

1. Records of Butterfly Migration in East Africa. C. B. Williams, *J. E. A. & Uganda Nat. Hist. Soc.*, No. 35, pp. 1-16, 1929.
2. Collected Records relating to Insect Migration, First and Second Series. C. B. Williams, *Trans. Ent. Soc., London,* Vol. 77, pp. 79-91, 1928; Vol. 79, pp. 139-170, 1930.
3. Locust-hoppers and Birds in East Africa. R. E. Moreau, *Bull. Ent. Res.*, Vol. 21, Part 2, pp. 141-145, 1930.
4. The Bird-population of a Settled Valley in the West Usambaras, Tanganyika Territory. R. E. Moreau, *J. Ecol.*, Vol. 19, No. 1, pp. 64-74, 1931.
5. The Filtration of the Virus of Streak Disease of Maize. H. H. Storey, *Ann. Appl. Biol.*, Vol. 19, No. 1, pp. 1-5, 1932.
6. The Estimation of Carbon in Plant Tissues, R. R. Worsley & F. J. Nutman, *Ann. Bot.*, Vol. 45, pp. 693-707, 1931.
7. A Bark Disease of Coffee in East Africa. H. H. Storey, *Ann. Appl. Biol.*, Vol. 19, No. 2, pp. 173-184, 1932.
8. Vegetation of Mpwapwa, Tanganyika Territory. P. J. Greenway, *J. Ecol.*, Vol. 21, No. 1, pp. 28-43, 1933.
9. Pleistocene Climatic Changes and the Distribution of Life in East Africa. R. E. Moreau, *J. Ecol.*, Vol. 21, No. 2, pp. 415-435, 1933.
10. On the Food of the Red-billed Oxpecker. R. E. Moreau, *Bull. Ent. Res.*, Vol. 24, Part 3, pp. 325-335, 1933.
11. The Inheritance by an Insect Vector of the Ability to Transmit a Plant Virus. H. H. Storey, *Proc. Roy. Soc. B.*, Vol. 112, pp. 45-60, 1932.
12. A Sulphur-deficiency Disease of the Tea Bush. H. H. Storey and R. Leach, *Ann. Appl. Biol.*, Vol. 20, Part 1, pp. 23-56, 1933.
13. A Note on the Distribution of *Gypohierax angolensis* (Gmel.), the Vulturine Fish-eagle. R. E. Moreau, *J. Animal Ecol.*, Vol. 2, No. 2, pp. 179-183, 1933.
14. Observations on the Desert Locust in East Africa from July, 1928, to April, 1929. C. B. Williams, *Ann. Appl. Biol.*, Vol. 20, No. 3, pp. 463-497, 1933.

15. A Contribution to Tropical African Bird-Ecology. R. E. Moreau, *J. Animal Ecol.*, Vol. 3, No. 1, pp. 41-69, 1934.
16. A Chemical Survey of the Waters of Mount Meru, Tanganyika Territory, especially with regard to their qualities for Irrigation. D. Sturdy, W. E. Calton and G. Milne. *J. E. A. & Uganda Nat. Hist. Soc.*, No. 45, pp. 1-38, 1933.
17. Investigations of the Mechanism of the Transmission of Plant Viruses. H. H. Storey, *Proc. Roy. Soc. B.*, Vol. 113, pp. 463-485, 1933.
18. Root-systems of *Coffea arabica*, Parts I and II. F. J. Nutman, *Emp. J. Exp. Agric.*, Vol. 1, pp. 271-284, 285-296, 1933.
19. Taxonomic and Field Notes on Some Birds of North-East Tanganyika Territory. W. L. Sclater and R. E. Moreau, *Ibis* (Ser. 13, Vol. 2), pp. 487-522, 656-683, 1932; (Ser. 13, Vol. 3), pp. 1-33, 187-219, 399-440, 1933.
20. Some East African Essential Oils. R. R. Worsley, *Bull. Imp. Inst.*, Vol. 32, pp. 253-270, 1934.
21. The Insecticidal Properties of some East African Plants. R. R. Worsley, *Ann. App. Biol.*, Vol. 21, pp. 649-669, 1934.
22. Root-systems of *Coffea arabica*, Part III. F. J. Nutman, *Emp. J. Exp. Agric.*, Vol. 2, pp. 293-392, 1934.
23. The Photodynamic Action of Methylene Blue on the Virus of a Plant Disease. H. H. Storey, *Ann. Appl. Biol.*, Vol. 21, pp. 588-589, 1934.
24. Some Eco-climatic Data for Closed Evergreen Forest in Tropical Africa. R. E. Moreau, *J. Linn. Soc. Zool.*, Vol. 39, pp. 285-293, 1935.
25. A Synecological Study of the Usambara Mountains, Tanganyika Territory, with particular reference to Birds. R. E. Moreau, *J. Ecol.*, Vol. 23, pp. 1-43, 1935.
26. Cinchona in Amani. R. R. Worsley, *Bull. Imp. Inst.*, Vol. 33, pp. 14-31, 1935.
27. Some Suggested Units of Classification and Mapping, particularly for East African Soils. G. Milne, *Soil Research*, Vol. 4, pp. 183-198, 1935.
28. Studies on the Ecology of Coffee Plantations in East Africa, I: The Climate and Eco-climates of Coffee Plantations. T. W. Kirkpatrick, Published by the Crown Agents for the Colonies, London, 1935.
29. A Short Geographical Account of the Soils of East Africa. G. Milne, in collaboration with East African soil chemists. *Trans. 3rd Internat. Cong. Soil Sci.*, Vol. 1, pp. 270-274, 1935.
30. Composite Units for the Mapping of Complex Soil Associations. G. Milne, *Ibid.*, pp. 345-347, 1935.
31. A Provisional Soil Map of East Africa. G. Milne, in collaboration with East African soil chemists. *Ibid.*, pp. 266-270, 1935.
32. A critical Analysis of the Distribution of Birds in a Tropical African Area. R. E. Moreau, *J. Animal Ecol.*, Vol. 4, pp. 167-191, 1935.
33. A Contribution to the Ornithology of Kilimanjaro and Mt. Meru. R. E. Moreau. *P. Z. S. London*, 1935, pp. 843-891.
34. The Insecticidal Properties of some East African Plants: 2 *Mundulea suberosa* Bentham, Pt. I Insecticidal Properties. R. R. Worsley. *Ann. Appl. Biol.*, Vol. 23, No. 2, pp. 311-328. 1936.
35. Mundulea Fish Poison. P. J. Greenway. *Kew Bull.*, No. 4, 1936.
36. A Provisional Soil Map of East Africa (Kenya, Uganda, Tanganyika and Zanzibar) with explanatory memoir. G. Milne in collaboration with East African Soil Chemists. Published by the Crown Agents for the Colonies, London, 1936.

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